# VIIRS Surface Reflectance Science Processing Algorithm (SURFREFLECT_SPA) User's Guide

**Version 1.5.08.04**

August 2014


**GODDARD SPACE FLIGHT CENTER**
**GREENBELT, MARYLAND**

# VIIRS Surface Reflectance Science Processing Algorithm

# SURFREFLECT_SPA

## General

The NASA Goddard Space Flight Center's (GSFC) Direct Readout Laboratory (DRL), Code 606.3 developed this software for the International Polar Orbiter Processing Package (IPOPP). IPOPP maximizes the utility of Earth science data for making real-time decisions by giving fast access to instrument data and derivative products from the Suomi National Polar-orbiting Partnership (SNPP), Aqua, and Terra missions and, in the future, the Joint Polar Satellite System (JPSS) mission.

Users must agree to all terms and conditions in the Software Usage Agreement on the DRL Web Portal before downloading this software.

Software and documentation published on the DRL Web Portal may occasionally be updated or modified. The most current versions of DRL software are available at the DRL Web Portal:

http://directreadout.sci.gsfc.nasa.gov/?id=software

Questions relating to the contents or status of this software and its documentation should be addressed to the DRL via the Contact DRL mechanism at the DRL Web Portal:

http://directreadout.sci.gsfc.nasa.gov/?id=dspContent&cid=66

## Algorithm Wrapper Concept

The DRL has developed an algorithm wrapper to provide a common command and execution interface to encapsulate multi-discipline, multi-mission science processing algorithms. The wrapper also provides a structured, standardized technique for packaging new or updated algorithms with minimal effort.

A Science Processing Algorithm (SPA) is defined as a wrapper and its contained algorithm. SPAs will function in a standalone, cross-platform environment to serve the needs of the broad Direct Readout community. Detailed information about SPAs and other DRL technologies is available at the DRL Web Portal.

## Software Description

This software package contains the Visible Infrared Imaging Radiometer Suite (VIIRS) Surface Reflectance Science Processing Algorithm (SURFREFLECT_SPA). The VIIRS Surface Reflectance algorithm takes as inputs VIIRS M-band Sensor Data Record (SDR) products; VIIRS I-band SDR products; the VIIRS M-Band Terrain-Corrected Geolocation product; the VIIRS I-Band Terrain-Corrected Geolocation product; the VIIRS Cloud Mask Intermediate Product (IP); the Aerosol Optical Thickness IP; and the Aerosol Model Index IP and meteorological ancillary. The algorithm produces the mission-compliant VIIRS Surface Reflectance HDF5 IP.

The SPA functions in two modes: Standalone, or as an IPOPP plug-in.

**Software Version**

Version 1.4 of the DRL algorithm wrapper was used to package the SPA described in this document. The Surface Reflectance algorithm has been ported from the Interface Data Processing Segment (IDPS) OPS Version 1.5.08.04.

Enhancements to this SPA include:

- algorithm updated to version 1.5.08.04;
- capability to process compressed and/or chunked HDF5 input files;
- updated Lookup Tables (LUTs).

This software will execute on a 64-bit computer, and has been tested with the following operating systems:

a) Fedora 18 X86_64;

b) CentOS Linux 6.4 X86_64;

c) OpenSUSE Linux 12.1 X86_64;

d) Kubuntu 13.04 X86_64.

**Credits**

The VIIRS Surface Reflectance algorithm was provided to the DRL by the JPSS Mission. This algorithm was ported to run outside of the IDPS by the DRL in collaboration with the Land Product Evaluation and Algorithm Test Element (LPEATE).

**Prerequisites**

To run this package, you must have the Java Development Kit (JDK) or Java Runtime Engine (JRE) (Java 1.6.0_25 or higher) installed on your computer, and have the Java installation bin/ subdirectory in your PATH environment variable. This package contains 64-bit binaries statically pre-compiled on an x86-compatible 64-bit computer running under Fedora 14, using gcc 4.5.1.

**Program Inputs and Outputs**

The SPA uses the following inputs:

a) VIIRS Moderate Resolution Sensor Data products (SVM01, 02, 03, 04, 05, 07, 08, 10, 11);

b) VIIRS Image Resolution Sensor Data products (SVI01, 02, 03),

c) VIIRS Moderate Resolution Terrain-Corrected Geolocation product (GMTCO);

d) VIIRS Image Resolution Terrain-Corrected Geolocation product (GITCO);

e) VIIRS Cloud Mask IP (IICMO);

f) Aerosol Optical Thickness IP (IVAOT);

g) Aerosol Model Index IP (IVAMT);

h) meteorological ancillary.

The SPA produces the mission-compliant VIIRS Surface Reflectance HDF5 IP as output.

**Installation and Configuration**

**Installing as a Standalone Application:**

Download the SURFREFLECT_1.5.08.04_SPA_1.4.tar.gz and SURFREFLECT_1.5.08.04_SPA_1.4_testdata.tar.gz (optional) files into the same directory.

Decompress and un-archive the SURFREFLECT_1.5.08.04_SPA_1.4.tar.gz and SURFREFLECT_1.5.08.04_SPA_1.4_testdata.tar.gz (optional) files:

```
$ tar -xzf SURFREFLECT_1.5.08.04_SPA_1.4.tar.gz
$ tar -xzf SURFREFLECT_1.5.08.04_SPA_1.4_testdata.tar.gz
```

This will create the following subdirectories:

```
SPA
    SurfReflect
        algorithm
        ancillary
        station
        testdata
        testscripts
        wrapper
```

**Installing into an IPOPP Framework:** This SPA can also be installed dynamically into an IPOPP framework to automate production of SURFREFLECT_SPA data products. The SPA installation process will install SPA station(s) into IPOPP. An SPA station is an IPOPP agent that provides the mechanism necessary for running an SPA automatically within the IPOPP framework. Once this SPA is installed, users must enable the station(s) corresponding to this SPA along with any other pre-requisite station(s). Instructions for installing an SPA and enabling its stations are contained in the IPOPP User's Guide (available on the DRL Web Portal). The SPA stations associated with this SPA are listed in Appendix A.

**Software Package Testing and Validation**

The testscripts subdirectory contains test scripts that can be used to verify that your

current installation of the SPA is working properly, as described below. Note that the optional SURFREFLECT_1.5.08.04_SPA_1.4_testdata.tar.gz file is required to execute these testing procedures.

*Step 1:* cd into the testscripts directory.
*Step 2:* There is a script named run-vsurfrefl inside the testscripts directory.
To run the Surface Reflectance algorithm, use

```
$ ./run-vsurfrefl
```

A successful execution usually requires 2 minutes or more, depending on the speed of your computer and the size of the granule. If everything is working properly, the scripts will terminate with a message such as:

```
Output viirs.srflip is
/home/ipopp/drl/SPA/SurfReflect/testdata/output/IVISR_npp_d20130323_t1851552.h5
```

You can cd to the output directory to verify that the science products exist. Test output product(s) are available for comparison in the testdata/output directory. These test output product(s) were generated on a 64-bit PC architecture computer running Fedora 14. The output products serve as an indicator of expected program output. Use a comparison utility (such as diff, h5diff, etc.) to compare your output product(s) to those provided in the testdata/output directory. Locally generated files may differ slightly from the provided output files because of differences in machine architecture or operating systems.

If there is a problem and the code terminates abnormally, the problem can be identified using the log files. Log files are automatically generated within the directory used for execution. They start with stdfile* and errfile*. Other log and intermediate files may be generated automatically within the directory used for execution. They are useful for traceability and debugging purposes. However it is strongly recommended that users clean up log files and intermediate files left behind in the run directory before initiating a fresh execution of the SPA. Intermediate files from a previous run may affect a successive run and produce ambiguous results. Please report any errors that cannot be fixed to the DRL.

**Program Operation**

In order to run the package using your own input data, you can either use the run scripts within the wrapper subdirectories, or modify the test scripts within the testscripts subdirectory.

**To Use the Run Scripts**

**Identify the 'run' scripts:** The wrapper directory within this package contains one subdirectory named SurfReflect. The subdirectory contains an executable called 'run'. Execute 'run' within the correct wrapper subdirectory to generate the corresponding product. For instance, the 'run' within wrapper/SurfReflect is used for creating Surface Reflectance outputs. Note that to execute 'run', you need to have

java on your path.

**Specify input parameters using <label value> pairs:** To execute the 'run' scripts, you must supply the required input and output parameters. Input and output parameters are usually file paths or other values (e.g., an automatic search flag). Each parameter is specified on the command line by a <label value> pair. Labels are simply predefined names for parameters. Each label must be followed by its actual value. Each process has its own set of <label value> pairs that must be specified in order for it to execute. Some of these pairs are optional, meaning the process would still be able to execute even if that parameter is not supplied. The two types of <label value> pairs that the SURFREFLECT_SPA uses are:

a) Input file label/values. These are input file paths. Values are absolute or relative paths to the corresponding input file.

b) Output file label/values. These are output files that are produced by the SPA. Values are absolute or relative paths of the files you want to generate.

The following tables contain labels, and their descriptions, required by the SURFREFLECT_SPA.

| Input File Labels | Description | Sources |
|---|---|---|
| viirs.svm01 | VIIRS Moderate Resolution Band M1 input HDF5 file path (SVM01) | The C-SDR SPA and the VIIRS-SDR SPA create these products.<br><br>DRL ftp site for real-time VIIRS SDRs over the eastern US region: ftp://is.sci.gsfc.nasa.gov/gsfcdata/npp/viirs/level1<br><br>These products can also be ordered from CLASS for other locations and times at www.class.noaa.gov<br><br>Filenames are of the form:<br><br>TTTTT_npp_dyyyymmdd_thhmmssS_ehhmmssS*.h5<br><br>Where TTTTT is a data product ID from the CDFCB (SVI01-03, SVM01-11, GMTCO, GITCO), and yyyy, mm, dd represents the year, month, and date for the start of the swath; the first hh, mm, ss, S represents the hour, minutes, seconds, and 10th of a second for the start of the swath and the second hh, mm, ss, S represents the end time of the swath. |
| viirs.svm02 | VIIRS Moderate Resolution Band M2 input HDF5 file path (SVM02) | |
| viirs.svm03 | VIIRS Moderate Resolution Band M3 input HDF5 file path (SVM03) | |
| viirs.svm04 | VIIRS Moderate Resolution Band M4 input HDF5 file path (SVM04) | |
| viirs.svm05 | VIIRS Moderate Resolution Band M5 input HDF5 file path (SVM05) | |
| viirs.svm07 | VIIRS Moderate Resolution Band M7 input HDF5 file path (SVM07) | |
| viirs.svm08 | VIIRS Moderate Resolution Band M8 input HDF5 file path (SVM08) | |
| viirs.svm10 | VIIRS Moderate Resolution Band M10 input HDF5 file path (SVM10) | |
| viirs.svm11 | VIIRS Moderate Resolution Band M11 input HDF5 file path (SVM11) | |
| viirs.gmtco | VIIRS M-Band Geolocation input HDF5 file path (GMTCO) | |
| viirs.svi01 | VIIRS Imagery Resolution Band I1 input HDF5 file path (SVI01) | |
| viirs.svi02 | VIIRS Imagery Resolution Band I2 input HDF5 file path (SVI02) | |
| viirs.svi03 | VIIRS Imagery Resolution Band I3 input HDF5 file path (SVI03) | |
| viirs.gitco | VIIRS I-Band Geolocation input HDF5 file path (GITCO) | |
| viirs.aotip | Aerosol Optical Thickness IP input HDF5 file path (IVAOT) | The AEROSOL SPA creates these products.<br>DRL ftp site for real-time VIIRS Aerosol IP over the eastern US region: ftp://is.sci.gsfc.nasa.gov/gsfcdata/npp/viirs/level2<br><br>These products can also be ordered from CLASS for other locations and times at |
| viirs.amiip | Aerosol Model Information IP input HDF5 file path (IVAMT) | |

| Input File Labels | Description | Sources |
|---|---|---|
| | | www.class.noaa.gov<br><br>Filenames are of the form:<br><br>TTTTT_npp_dyyyymmdd_thhmmssS_ehhmmssS*.h5<br><br>Where TTTTT is a data product ID from the CDFCB (IVAOT, IVAMT), and yyyy, mm, dd represents the year, month, and date for the start of the swath; the first hh, mm, ss, S represents the hour, minutes, seconds, and 10th of a second for the start of the swath and the second hh, mm, ss, S represents the end time of the swath |
| viirs.cmip | Cloudmask IP input HDF5 file path (IICMO) | The CLOUDMASK SPA creates this product.<br><br>DRL ftp site for real-time VIIRS Cloud Mask IP over the eastern US region: ftp://is.sci.gsfc.nasa.gov/gsfcdata/npp/viirs/level2<br><br>These products can also be ordered from CLASS for other locations and times at www.class.noaa.gov<br><br>Filenames are of the form:<br><br>IICMO_npp_dyyyymmdd_thhmmssS_ehhmmssS*.h5<br><br>Where yyyy, mm, dd represents the year, month, and date for the start of the swath; the first hh, mm, ss, S represents the hour, minutes, seconds, and 10th of a second for the start of the swath and the second hh, mm, ss, S represents the end time of the swath |
| ncep_met | NCEP Numerical Weather Prediction GRIdded Binary (GRIB) File. This can be either a Global Data Assimilation System (GDAS1, 6 hourly, 1 degree global) analysis field file or a Global Model Forecast Fields (GFS) file. The SPA requires GDAS and GFS files in grib1 format. | Current Data:<br>ftp://is.sci.gsfc.nasa.gov/ancillary/temporal/global/gdas (for GDAS)<br><br>ftp://is.sci.gsfc.nasa.gov/ancillary/temporal/global/gfs (for GFS)<br><br>Archived Data:<br>ftp://is.sci.gsfc.nasa.gov/ArchivedAncillary/temporal/global/gdas<br><br>Filenames are of the form: |

| Input File Labels | Description | Sources |
|---|---|---|
| | | gdas1.PGrbF00.yymmdd.hhz<br><br>Where yy represents the last two digits of the year, and mm, dd, and hh represent the month, day and hour of the date and time of the GRIB file's data. |

| Output File Labels | Description | Destination (when SPA is installed in IPOPP) |
|---|---|---|
| viirs.srflip | Surface Reflectance IP output HDF file path | /raid/pub/gsfcdata/npp/viirs/level2/IVISR_npp_dyyyymmdd_thhmmssS_ehhmmssS*.hdf<br><br>Where yyyy, mm, dd represents the year, month, and date for the start of the swath; the first hh, mm, ss, S represents the hour, minutes, seconds, and $10^{th}$ of a second for the start of the swath and the second hh, mm, ss, S represents the end time of the swath |

**Execute the 'run':** The following script shows an example of command line to run the Surface Reflectance algorithm from the testscripts directory:

```
$   ../wrapper/SurfReflect/run \
 viirs.svm01 ../testdata/input/SVM01_npp_d20130323_t1851552_e1853194_b07270_c20130329144557882056_noaa_ops.h5
\
 viirs.svm02 ../testdata/input/SVM02_npp_d20130323_t1851552_e1853194_b07270_c20130329144420790139_noaa_ops.h5
\
 viirs.svm03 ../testdata/input/SVM03_npp_d20130323_t1851552_e1853194_b07270_c20130329144447345002_noaa_ops.h5
\
 viirs.svm04 ../testdata/input/SVM04_npp_d20130323_t1851552_e1853194_b07270_c20130329144448698975_noaa_ops.h5
\
 viirs.svm05 ../testdata/input/SVM05_npp_d20130323_t1851552_e1853194_b07270_c20130329144411503651_noaa_ops.h5
\
 viirs.svm07 ../testdata/input/SVM07_npp_d20130323_t1851552_e1853194_b07270_c20130329144352689405_noaa_ops.h5
\
 viirs.svm08 ../testdata/input/SVM08_npp_d20130323_t1851552_e1853194_b07270_c20130329144555556037_noaa_ops.h5
\
 viirs.svm10 ../testdata/input/SVM10_npp_d20130323_t1851552_e1853194_b07270_c20130329144540110579_noaa_ops.h5
\
 viirs.svm11 ../testdata/input/SVM11_npp_d20130323_t1851552_e1853194_b07270_c20130329144429442736_noaa_ops.h5
\
 viirs.gmtco ../testdata/input/GMTCO_npp_d20130323_t1851552_e1853194_b07270_c20130329144438416689_noaa_ops.h5
\
 viirs.svi01 ../testdata/input/SVI01_npp_d20130323_t1851552_e1853194_b07270_c20130329144457901126_noaa_ops.h5 \
 viirs.svi02 ../testdata/input/SVI02_npp_d20130323_t1851552_e1853194_b07270_c20130329144508343727_noaa_ops.h5 \
 viirs.svi03 ../testdata/input/SVI03_npp_d20130323_t1851552_e1853194_b07270_c20130329144453693755_noaa_ops.h5 \
 viirs.gitco ../testdata/input/GITCO_npp_d20130323_t1851552_e1853194_b07270_c20130329144559539969_noaa_ops.h5 \
 viirs.aotip ../testdata/input/IVAOT_npp_d20130323_t1851552_e1853194.h5 \
 viirs.amiip ../testdata/input/IVAMI_npp_d20130323_t1851552_e1853194.h5 \
 viirs.cmip ../testdata/input/IICMO_npp_d20130323_t1851552_e1853194_b07270_c20130618184731407557_noaa_ops.h5 \
 ncep_met ../testdata/input/gdas1.PGrbF00.*z \
 viirs.srflip ../testdata/output/IVISR_npp_d20130323_t1851552.h5
```

A successful execution usually requires 2 minutes or more, depending on the speed of your computer and the size of the granule. If execution fails, you will see an error message indicating the cause of failure (e.g., a file cannot be found, or a label cannot be recognized). Correct it and run again. If the problem has some other cause, it can be identified using the log files. Log files are automatically generated within the directory used for execution. They start with stdfile* and errfile* and can be deleted after execution. Other log and intermediate files may be generated automatically within the directory used for execution. They are useful for traceability and debugging purposes. However it is strongly recommended that users clean up log files and intermediate files left behind in the run directory before initiating a fresh execution of the SPA. Intermediate files from a previous run may affect a successive run and produce ambiguous results. The 'run' can be executed from any directory the user chooses. This can be done by prefixing it with the file path for the 'run' script.

**NOTES:**

1. Either GDAS or Global Model Forecast Fields (GFS) files may be used for the ncep_met label. Try to use a GDAS file that is within ±3 hours of the SDR observation time. If that file is not available (as is often the case for real-time processing), use a GFS file instead. The naming convention for grib1 gfs files is gfs.thh.yymmdd.pgrbfxx (here yymmddd and hh represent analysis time, and xx represents forecast time step). Thus a file named gfs.t12.100201.pgrbf03 corresponds to 1500 hours (12+3) UTC on February 1, 2010. If you have to choose GFS data as input, you should attempt to use a file that is within ±1.5 hours of the SDR file. If there is more than one such GFS file, use the one with the smaller forecast time step. For example, if your data time is 15 UTC, you should try to use the 3 hour forecast field from the 1200 UTC model run, instead of the 9 hour forecast field from the 0600 UTC run. If no GDAS or GFS file is available using the above logic, use a GDAS file that is closest in time but within ±7 days of the granule time.

2. The Surface Reflectance algorithm requires the Aerosol Optical Thickness IP and Aerosol Model Index IP, which are produced by the Aerosol SPA. The Aerosol SPA will not produce the aerosol products if the input swath has an insufficient number of daytime granules. Therefore, the Surface Reflectance SPA will not be able to process a swath with an insufficient number of daytime granules.

**To Use the Scripts in the testscripts Directory**

One simple way to run the algorithms from the directory of your choice using your own data is to copy the run-vsurfrefl script from the testscripts directory to the selected directory. Change the values of the variables like WRAPPERHOME, INPUTHOME and OUTPUTHOME to reflect the file paths of the wrapper directories and the input/output file paths. Then modify the input/output file name variables. Run the script to process your data.

# Appendix A
# SPA Stations

Installation of this SPA in IPOPP mode will make the SPA stations listed in Table A-1 available to IPOPP. These stations along with any other pre-requisite stations (listed in Table A-2) will need to be enabled to allow IPOPP to automate production of the VIIRS-AF data products. Further, users who wish to generate image products from the data products generated by this SPA will need to enable the image-generating stations listed in Table A-3. The SPAs containing the pre-requisite and the image-generating stations listed in Tables A-2 and A-3 can be downloaded from the DRL Web Portal, in case they are not already available in your IPOPP installation. Details about these other SPAs are available in the respective SPA User's Guides. Please refer to the IPOPP User's Guide for instructions on how to install an SPA in IPOPP and enable the corresponding stations.

**Table A-1. SPA Stations**

| SPA stations for this SPA | Data Products produced |
|---|---|
| SurfRefl | VIIRS Land Surface Reflectance IP |

**Table A-2. Pre-requisite Stations**

| Pre-requisite SPA stations | SPA in which they are available |
|---|---|
| VIIRS_C-SDR<br>**OR**<br>VIIRS-SDR<br><br>CloudMask<br>Aerosol | C-SDR_SPA<br><br>VIIRS-SDR_SPA<br><br>CLOUDMASK_SPA<br>AEROSOL_SPA |

**WARNING:** The stations VIIRS-SDR and VIIRS_C-SDR must never be run simultaneously.

**Table A-3. Image-generating Stations**

| Image-generating stations | SPA in which they are available |
|---|---|
| vsurfreflh5d-geotiff | H2G_SPA |

**NOTE:** Please refer to the H2G_SPA User's Guide for more details about the image products, including their locations and filename patterns when they are generated in IPOPP.